Preliminary Assessment of Road Mortality in Chilabothrus exsul, the Northern Bahamas Boa.

Reynolds, R. Graham; Giery, Sean T. ; Jesse, W.A.M.; Quach, Quynh H.

published in
Caribbean Naturalist
2016

document version
Publisher's PDF, also known as Version of record

Caribbean Naturalist

No. 34 2016

Preliminary Assessment of Road Mortality in *Chilabothrus exsul*, the Northern Bahamas Boa

R. Graham Reynolds, Sean T. Giery, Wendy A.M. Jesse, and Quynh N. Quach

The *Caribbean Naturalist . . .*

- A peer-reviewed and edited interdisciplinary natural history science journal with a regional focus on the Caribbean (ISSN 2326-7119 [online]).
- Featuring research articles, notes, and research summaries on terrestrial, fresh-water, and marine organisms, and their habitats. The journal's versatility also extends to publishing symposium proceedings or other collections of related papers as special issues.
- Focusing on field ecology, biology, behavior, biogeography, taxonomy, evolution, anatomy, physiology, geology, and related fields. Manuscripts on genetics, molecular biology, anthropology, etc., are welcome, especially if they provide natural history insights that are of interest to field scientists.
- Offers authors the option of publishing large maps, data tables, audio and video clips, and even powerpoint presentations as online supplemental files.
- Proposals for Special Issues are welcome.
- Arrangements for indexing through a wide range of services, including Web of Knowledge (includes Web of Science, Current Contents Connect, Biological Abstracts, BIOSIS Citation Index, BIOSIS Previews, CAB Abstracts), PROQUEST, SCOPUS, BIOBASE, EMBiology, Current Awareness in Biological Sciences (CABS), EBSCOHost, VINITI (All-Russian Institute of Scientific and Technical Information), FFAB (Fish, Fisheries, and Aquatic Biodiversity Worldwide), WOW (Waters and Oceans Worldwide), and Zoological Record, are being pursued.
- The journal staff is pleased to discuss ideas for manuscripts and to assist during all stages of manuscript preparation. The journal has a mandatory page charge to help defray a portion of the costs of publishing the manuscript. Instructions for Authors are available online on the journal's website (www.eaglehill.us/cana).
- Co-published with the *Northeastern Naturalist* (Print ISSN # 1092-6194, Online ISSN # 1938-5307), the *Southeastern Naturalist* (Print ISSN # 1528-7092, Online ISSN # 1938-5412), and *Urban Naturalist* (ISSN # 2328-8965 [online]). Together these journals provide an integrated publishing and research resource for all of eastern mainland North America and the offshore waters and islands from Canada south to the Caribbean region, as well as urban areas worldwide.
- Available online in full-text version on the journal's website (www.eaglehill.us/cana). Arrangements for inclusion in the BioOne database (www.bioone.org, a collaborative effort of Allen Press, AIBS, et al.), EBSCOhost product line, and the Proquest Information and Learning databases (www.il.proquest.com) are being pursued.
- May be ordered through any major subscription service.

Cover Photograph: Juvenile Northern Bahamas Boa (*Chilabothrus exsul*). Photograph © Quynh N. Quach.

CARIBBEAN NATURALIST

The ***Caribbean Naturalist*** (ISSN # 2326-7119) is published by the Eagle Hill Institute, PO Box 9, 59 Eagle Hill Road, Steuben, ME 04680-0009. Phone 207-546-2821, FAX 207-546-3042. E-mail: office@eaglehill.us. Webpage: www.eaglehill.us/cana.

Periodical postage paid in Steuben, ME and additional mailing offices. **Special issue proposals are welcome**. On-line secure subscription ordering: rate per year for Caribbean subscribers - $15 regular, $10 students, $70 organizations; for Non-Caribbean subscribers - $20 regular, $15 students, $90 organizations. **Authors**: submission guidelines are available at www.eaglehill.us/cana. **Co-published journals:** The *Northeastern Naturalist* (ISSN 1092-6194 [print], ISSN 1938-5307 [online]), the *Southeastern Naturalist* (ISSN 1528-7092 [print], ISSN 1938-5412 [online]), and the *Urban Naturalist* (ISNN #2328-8965), journals with separate Boards of Editors. The Eagle Hill Institute is a tax exempt 501(c)(3) nonprofit corporation of the State of Maine (Federal ID # 010379899).

Preliminary Assessment of Road Mortality in *Chilabothrus exsul*, the Northern Bahamas Boa

R. Graham Reynolds[1,5,*], Sean T. Giery[2], Wendy A.M. Jesse[3], and Quynh N. Quach[4]

Abstract - The Northern Bahamas Boa (*Chilabothrus exsul*) is a secretive species of boid snake that occupies a relatively small range on the Northern Bahamas Bank. Little is known regarding the natural history of this species or its conservation status. As a component of conducting an IUCN Red List Assessment for the species, we quantified road mortality, or the death of individual snakes on roads caused by vehicle strikes, on 2 transects on Abaco Island, Bahamas. We surveyed transects 21 times during sampling sessions in June 2015, August 2015, and January 2016. We found a total of 11 boas over 1379.2 km of transect sampling. This represented an encounter rate of 0.008 boas/km, and an average of 0.006 dead boas per km and 0.381 dead boas per transect survey. This study is the first explicit attempt to quantify anthropogenically induced mortality in West Indian boas, and the first to document significant road mortality in the genus. Our data suggest that roads should be considered a significant source of mortality for the Northern Bahamas Boa, a consideration that is crucial to preparing an accurate conservation assessment and action plan for the species.

Introduction

Roads are a major source of mortality for wildlife (Forman and Alexander 1998, Forman et al. 2003, Trombulak and Frissell 2000). Populations can be affected through the simple reduction of individuals and/or the differential removal of reproductively valuable individuals, especially mature females, owing to behavioral differences (Row et al. 2007, Steen and Gibbs 2004). Recent research is contributing to our understanding of the effects of road mortality on reptile populations (Gibbs and Shriver 2002, Kjoss and Litvaitis, 2001, Rosen and Lowe 1994, Shepard et al. 2008, Shine et al. 2004, Steen and Gibbs 2004, Steen et al. 2006). For example, road strikes have depleted local populations of *Pantherophis* (*Elaphe*) *obsoletus* (Say in James) (Black Ratsnake) through the removal of reproductive females (Row et al. 2007). Populations of the same species can also be differentially impacted by roads, and in regions with moderate to high road density, annual mortality in *Nerodia erythrogaster neglecta* (Conant) (Copperbelly water snake) populations due to car strikes may be as high as 21% (Roe et al. 2006).

[1]Department of Organismic and Evolutionary Biology and Museum of Comparative Zoology, Harvard University, Cambridge, MA 02138, USA. [2]Department of Applied Ecology, North Carolina State University, Raleigh, NC 27695, USA. [3]Department of Ecological Science, Section Animal Ecology, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands. [4]Department of Biology, University of Massachusetts Boston, Boston, MA 02125, USA. [5]Current address - Department of Biology, University of North Carolina Asheville, Asheville, NC 28804. [*]Corresponding author - greynold@unca.edu.

Manuscript Editor: Robert Powell

Research on road mortality in vertebrates has increased substantially in the last 2 decades; however, the majority of studies are restricted to continental regions, and few data are available for islands. Some Caribbean islands have high densities of paved roads. For example, Puerto Rico's road density (2.5 km road/km^2) exceeds that of most European countries (1–2 km road/km^2; International Road Federation 2015). Recent reviews of the conservation status of Caribbean reptiles do not mention roads as a distinct source of mortality. Instead, roads are treated under general concerns such as "human disturbance" (e.g., Tolson and Henderson 2011). On the Cayman Islands, *Cyclura* (rock iguanas) have been severely impacted by vehicular use, which, in combination with introduced predators, is driving populations to extinction (Burton 2012, Echternacht et al. 2011). Determining the magnitude of traffic-related demographic effects on species is the first step toward understanding, avoiding, and mitigating these impacts.

The first record of *Chilabothrus exsul* (Netting and Goin) (Northern Bahamas Boa) being found on a road was from 1965, when the Great Abaco Highway (Fig. 1) was surveyed for boas (Sheplan and Schwartz 1974). Those authors discovered a single dead individual, likely killed by a passing motorist. Since that time, the Great Abaco Highway was developed as a two-lane blacktop artery running the length of Abaco Island, throughout the majority of the range of *C. exsul* (Fig. 1). In 1997, a long blacktop spur was built linking the settlements of Cherokee and Little Harbour to the Great Abaco Highway. This new two-lane road permits high-speed travel through an area containing what is thought to be a significant population of *C. exsul*. Here we provide an estimate of road mortality for this small, cryptic, and poorly known boid. We conducted a pilot study to establish a database quantifying road mortality in this species. These data are important for applied conservation of the species, and will contribute to its International Union for the Conservation of Nature (IUCN) Red List assessment. Such assessments rely on an accurate understanding of threats to a species, including major sources of mortality, to justify listing under Red List Criteria A through C (IUCN 2015). To date, no information exists on road mortality in any Bahamian boa species, though boas of 3 species are routinely found dead on roads throughout their ranges in the Lucayan (Bahamas and Turks and Caicos) Archipelago (Reynolds and Gerber 2012; R.G. Reynolds, pers. oberv.).

Natural History and Site Description

Chilabothrus exsul (Fig. 2) is 1 of 4 boid species endemic to the Lucayan Archipelago (Reynolds et al. 2013, 2016; Tolson and Henderson 1993). One of the smallest West Indian boa species, it is restricted to the Northern Bahamas Bank, where it occurs on Abaco Island; the satellite islands of Tilloo Cay, Elbow Cay, Sandy Cay, Man-o-War Cay, Green Turtle Cay; and possibly on the eastern end of Grand Bahama (Buckner et al. 2012, Krysko et al. 2013, Schwartz and Henderson 1991). While detailed natural history studies are lacking for this species (Henderson and Powell 2009), populations appear localized and apparently are associated with coppice, a broadleaf evergreen forest developed over karst and dominated by the

hardwoods *Sideroxylon foetidissimum* Jacq. (False Mastic), *Swietenia mahagoni* (L.) Jacq. (West Indian Mahogany), *Metopium toxiferum* (L.) Krug & Urb. (Poisonwood), and *Bursera simaruba* (L.) Sarg. (Gumbo Limbo) (Franklin and Steadman 2013). Individuals have been observed in native *Pinus caribaea* var. *bahamensis*

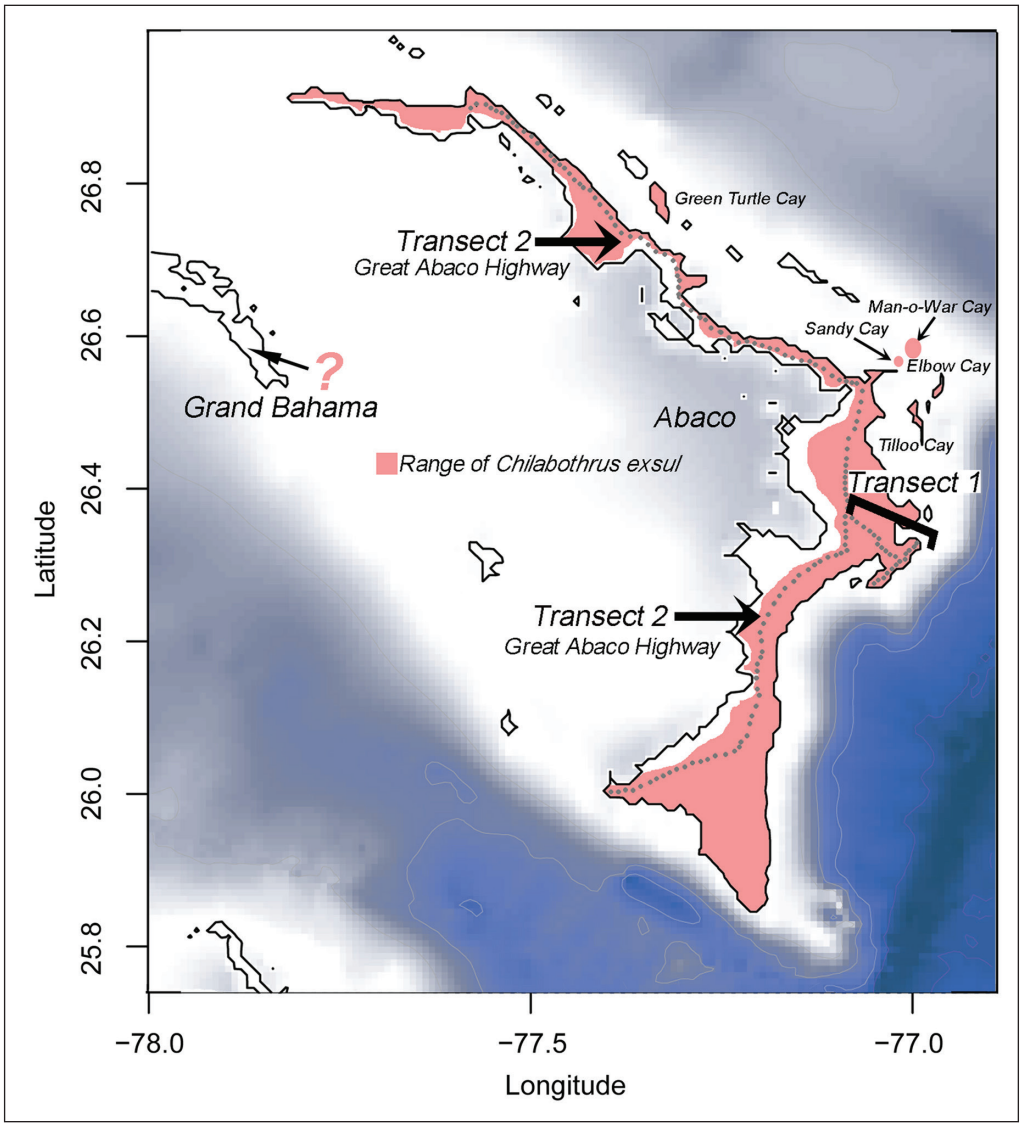

Figure 1. Map of the study area encompassing Abaco Island and the eastern end of Grand Bahama Island, Commonwealth of the Bahamas. Pink shading indicates the potential (not necessarily the realized) range of *Chilabothrus exsul* (Northern Bahamas Boa) on Abaco and some associated cays. Our 2 transects are shown as gray dotted lines, where Transect 2 constitutes the majority of the Great Abaco Highway (except for Little Abaco) and Transect 1 in eastern Abaco is a spur connecting the settlements of Cherokee and Little Harbour to the Highway. Note that it is not known whether boas occur on Grand Bahama Island to the west.

(Grisebach) W.H. Barrett & Golfari (Caribbean Pine) forest (Henderson and Powell 2009, Sheplan and Schwartz 1974), although at a much lower frequency (R.G. Reynolds et al., pers. oberv.). Although very little is known regarding the life history of *C. exsul* (Henderson and Powell 2009), it is considered to be long-lived, with individuals reaching ages over 20 years in captivity (Snider and Bowler 1992). Females likely produce litters biennially (Tolson and Henderson 1993), and prey items consist of lizards, birds, and small mammals (Tolson and Henderson 1993). *Chilabothrus exsul* is nocturnal, foraging slowly to find sleeping prey items, likely similar to *C. chrysogaster* (Cope) (Turks Island Boas; Reynolds and Gerber 2012), which might lead to prolonged crossing of roads by individual snakes at night and, hence, increased mortality caused by vehicle strikes. Largely as a consequence of their restricted range, *C. exsul* is considered to be of conservation concern and is listed on the Convention on International Trade in Endangered Species (CITES) Appendix II.

We conducted diurnal and nocturnal road surveys on Abaco Island, Bahamas, to assess frequency of road capture and mortality in boas. We established 2 transects: Transect 1 encompasses the relatively new Cherokee Road in the vicinity of Cherokee Sound, from the settlement of Cherokee (26.2829°, -77.0510° WGS84), to Little Harbour (26.3269°, -76.9966° WGS84), to the intersection with the Great Abaco Highway (26.3727°, -77.0982° WGS84). Transect 2 was exclusively on the Great Abaco Highway, from the Little Abaco Bridge (26.9020°, -77.5802° WGS84) in the north to the turnoff to Cherokee Sound in the south (26.3727°, -77.0982° WGS84). We especially designed these transects to traverse both a suspected high-density area for boas (Transect 1) as well as the majority of the range of this species (Transect 2) (Fig. 1).

Our Transect 1 consisted of a 41.2-km loop, which included a 16-km backtrack, on both blacktop (39.1 km) and unfinished road surfaces (3.7 km). We selected this transect to maximize both distance covered and sampling of a variety of habitat types, including mature Caribbean Pine forest, agricultural land, mature and regenerating coppice, and mangrove (*Rhizophora mangle* L. [Red Mangrove] and *Avicennia germinans* (L.) L. [Black Mangrove]) forest. For

Figure 2. Live *Chilabothrus exsul* found during nocturnal road surveys. On the left is a young-of-year female still exhibiting juvenile orange coloration. On the right is an adult female.

this transect, we undertook 7 surveys during 12–19 June 2015, three surveys during 7–9 August 2015, and 7 surveys during 6–25 January 2016. We conducted all visual surveys for boas and other snakes along this transect at speeds of 10–40 km/h from approximately 2000 h to 2400 h.

Transect 2 consisted of a 180-km stretch including a 90-km backtrack that we sampled on 4 occasions, twice during 12–19 June and twice during 7–9 August. The transect covers nearly the entire range of *C. exsul* (Fig. 1), and includes the majority of habitats found on Abaco Island (from mangroves and urban development to coppice and pineland). We surveyed this transect diurnally at speeds of 20–60 km/h, depending on traffic. This transect was considerably more difficult to survey, owing to increased traffic volume and high travel speed on this road.

Finally, we opportunistically recorded road-killed boas and other snake species outside of our transects, specifically in and around Marsh Harbour, Little Harbour, and Cherokee Sound.

Results

We surveyed a total of 700.4 km over the course of 17 sampling sessions on Transect 1. We found 7 boas during the surveys. We spotted 3 live animals as they were entering the roadway: 1 adult female (Fig. 2), 1 young adult male (Fig. 3), and 1 juvenile (young-of-year) undergoing ontogenetic color change (Fig. 2). We measured, photographed, genetically sampled, and subsequently released these individuals well off of the road. We found 4 dead boas consisting of 3 adult females

Figure 3. Live young male *Chilabothrus exsul* crossing the road leading to Little Harbour, Abaco.

and 1 adult male; all but one of which we found on blacktop road surface. Five of these 7 individuals were adjacent to coppice habitats, with 1 individual found crossing from mangrove forest to a coppice hillside. The other 2 boas were adjacent to a coppice/pine forest transition zone. In addition to the boas, we found 1 live and 2 dead *Cubophis vudii* (Cope) (Bahamian Racer) in a pine forest/agriculture transition region, as well as a single adult *Pantherophis guttatus* (L.) (Red Cornsnake) of unknown sex in coppice habitat in the vicinity of Yellowwood settlement (between the settlements of Little Harbour and Cherokee), which is only the third reported specimen of this introduced species on Abaco. The population of *Pantherophis guttatus* on the island is thought to be limited to this area (Giery 2013).

On Transect 2, we surveyed a total of 720 km over the course of the 4 sampling sessions. We found 4 dead boas on the Great Abaco Highway: 3 juveniles and 1 adult. Two juvenile boas were located between Marsh Harbour and the Cherokee turnoff, crossing between patches of extensive relatively mature pine forest. We found the other 2 boas, a juvenile and an adult female, between Marsh Harbour and Treasure Cay Airport in pine forest interspersed with coppice. These individuals had obviously emerged from coppice habitat onto the roadway. In addition, we found a single dead *Cubophis vudii* on the highway between Marsh Harbour and the Cherokee turnoff in pine forest habitat.

In addition to our transect surveys, we opportunistically encountered 9 boas outside of our established transects. We found 2 live (adult and juvenile) and 7 dead boas (4 adults and 3 juveniles) on roads within Marsh Harbour and within Little Harbour between 2011 and 2014. Many of these individuals were encountered in the town of Marsh Harbour, where they appear dependent on a relatively intact but narrow strip of coppice.

In summary, we found encounter rates of 0.01 boas/km for Transect 1 and 0.005 boas/km for Transect 2, for a total encounter rate of 0.008 boas/km based on nocturnal and diurnal road surveys on our 2 transects. We found an average of 0.381 dead and 0.142 live boas per survey, and 0.006 dead and 0.002 live boas per km.

Discussion

Our observations suggest that substantial numbers of *C. exsul* are being killed by vehicle strikes on Abaco Island. Additionally, all age classes (neonates to adults) and both sexes are being killed by vehicles. Extrapolation to annual mortality on these roads is challenging given that boa activity and vehicle-strike risk likely varies seasonally (Tolson and Henderson 1993). Nevertheless, for Transect 1, our data suggest that road mortality might reach an average of 1.6 boas per week or higher during summer and winter seasons. Such high mortality rates almost certainly represent an important demographic loss to these long-lived, range-restricted snakes. If these estimates are representative of the entire island of Abaco, our data suggest that hundreds of boas are killed annually by vehicle strikes alone.

While road mortality is likely an important anthropogenic source of mortality for *C. exsul*, a host of additional threats are present in the area; these include invasive, non-native predators and habitat loss. *Felis catus* L. (Domestic Cat) are

abundant throughout Abaco (Gnam 1990) and have been observed killing and consuming boas on multiple occasions (S.T. Giery, pers. observ.) In addition to cats, feral *Canis familiaris* L. (Domestic Dog), rats, *Sus scrofa* L. (Feral Pig; Netting and Goin 1944), and introduced *Procyon lotor* (L.) (Raccoon) likely also kill boas. The magnitude of mortality owing to invasive mammals is entirely unknown; yet, the reported extirpation of a population of "boas" (taxonomic identity unclear, possibly *Cubophis*) on Stanger's Cay, Abaco, following the introduction of *Sus scrofa* (Netting and Goin 1944), suggests that predation by feral animals is a substantial threat to snakes. Changing land use on Abaco (and throughout much of the Lucayan Archipelago) is also an important threat to snakes in the region. An increasing frequency of wildfires in combination with coastal and cay development erodes and fragments Abaco's remaining coppice habitat, which covers less than 10% of the island's total area (Franklin and Steadman 2013). The longevity and the biennial and relatively low reproductive output of West Indian boas (Tolson and Henderson 1993) suggests that *C. exsul* might be especially sensitive to abrupt increases in mortality. Coupled with its small geographic range, broad suite of acute anthropogenic threats, and the rapid rate of coastal development on Abaco, this species clearly is in serious need of monitoring and perhaps conservation intervention.

Conservation planners in the Caribbean have long focused on problems owing to habitat loss/degradation and invasive species. However, road mortality is an important conservation problem and deserves attention as well. Clearly, boas cross roads frequently enough to subject populations to high vehicular mortality. While our surveys were limited in time and scope, the results provide the first reports of road mortality for this species, or any species of Bahamian boa. Despite a limited understanding of road mortality in the Caribbean region, this threat is likely a pervasive one as suggested by reports for *C. inornatus* (Reinhardt) (Puerto Rican Boa; Reagan 1984) and *C. momensis granti* (Stull) (Virgin Islands Boa; Reynolds et al. 2015). Similar studies from mainland South America demonstrate the global threat of road mortality to tropical snakes, with reported rates of 0.014–0.047 snakes killed/km/day (Lynch 2012, Vargas-Salinas et al. 2011). Beyond providing initial mortality data on a rare endemic reptile, this study highlights the feasibility and utility of road surveys for gathering natural history and conservation information on a cryptic and secretive species, despite the reported difficulty of finding it (Sheplan and Schwartz 1974). We believe that road surveys can and should be implemented throughout the Caribbean region to better understand this often overlooked threat.

Data gathered from this study have been useful in assessing threats to *C. exsul*, which have informed the forthcoming IUCN Red List Assessment. However, data on the basic natural history of this species and others in the genus remain sparse. These knowledge gaps hinder an accurate assessment of harm posed by road mortality as well as the implementation of effective conservation actions. Future work on the *C. exsul* and other West Indian boas should focus on generating a better understanding of their natural history as well as the multitude of threats facing these unique animals.

Acknowledgments

We thank C. Layman and K. Rennirt for advice, support, and assistance in the field. We thank the Bahamas Department of Agriculture and the Bahamas Environment, Science, and Technology Commission, Ministry of the Environment, for research and export permits (CITES-2015/349). We are grateful for support from the Museum of Comparative Zoology, Harvard University, National Science Foundation (DEB-14063999 to S.T. Giery) and from BrakesForSnakes.org. We thank R. Powell and 2 anonymous reviewers for constructive comments on the manuscript.

Literature Cited

Buckner, S.D., R. Franz, and R.G. Reynolds. 2012. Bahama Islands and Turks & Caicos Islands. *In* R. Powell and R.W. Henderson (Eds.). Island Lists of West Indian Amphibians and Reptiles. Bulletin of the Florida Museum of Natural History 51:85–166.

Burton, F.J. 2012. *Cyclura lewisi*. The IUCN Red List of Threatened Species 2012. Available online at http://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T44275A2994409.en. Accessed 05 January 2016.

Echternacht, A.C., F.J. Burton, and J.M. Blumenthal. 2011. The amphibians and reptiles of the Cayman Islands: conservation issues in the face of invasions. Pp. 129–147, *In* A. Hailey, B.S. Wilson, and J.A. Horrocks (Eds.). Conservation of Caribbean Island Herpetofaunas, Vol. 2. Brill, Leiden, The Netherlands.

Forman, R.T.T., and L.E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207–231.

Forman, R.T.T., D. Sperling, J.A. Bissonette, A.P. Clevenger, C.D. Cutshall, V.H. Dale, L. Fahrig, R.L. France, C.R. Goldman, K. Heanue, J. Jones, F. Swanson, T. Turrentine, and T.C. Winter. 2003. Road Ecology. Island Press, Washington, DC.

Franklin, J., and D.W. Steadman 2013. Winter bird communities in pine woodland vs. broadleaf forest on Abaco, The Bahamas. Caribbean Naturalist 3:1–18.

Gibbs, J.P., and W.G. Shriver. 2002. Estimating the effects of road mortality on turtle populations. Conservation Biology 16:1647–1652.

Giery, S.T. 2013. First records of the Red Cornsnake (*Pantherophis guttatus*) from Abaco island, The Bahamas, and notes on their current distribution in the Greater Caribbean region. IRCF Reptiles and Amphibians 20:23–29.

Gnam, R.S. 1990. ICBP: Conservation of the Bahama Parrot. American Birds 44:32–36.

Henderson, R.W., and R. Powell. 2009. Natural History of West Indian Reptiles and Amphibians. The University of Florida Press, Gainesville, FL, USA.

International Road Federation. 2015. Countries compared by transport > road density > km of road per 100 sq. km of land area: Countries compared. Aggregates compiled by NationMaster.com. Available online at http://www.nationmaster.com/country-info/stats/Transport/Road-density/Km-of-road-per-100-sq.-km-of-land-area. Accessed 3 March 2016.

Internaltion Union for Conservation of Nature (IUCN). 2015. The IUCN Red List of Threatened Species. Version 2015.1. Avilable online at http://www.iucnredlist.org. Accessed 1 August 2015.

Kjoss, V.A., and J.A. Litvaitis. 2001. Community structure of snakes in a human-dominated landscape. Biological Conservation 98:285–292.

Krysko, K.I., D.W. Steadman, J.I. Mead, N.A. Albury, C.A. MacKenzie-Krysko, and S.L. Swift. 2013. New island records for amphibians and reptiles on the Little Bahama Bank, Commonwealth of the The Bahamas. IRCF Reptiles and Amphibians 20:152–154.

Lynch, J.D. 2012. El contexto de las serpientes de Columbia con un análisis de la amenazas en contra de su conservación. Revista - Academia Colombiana de Ciencias Exactas, Físicas, y Naturales 36:435–449.

Netting, M.G., and C.J. Goin. 1944. Another new boa of the genus *Epicrates* from the Bahamas. Annals of the Carnegie Museum 306:71–76.

Reagan, D.P. 1984. Ecology of the Puerto Rican Boa (*Epicrates inornatus*) in the Luquillo Mountains of Puerto Rico. Caribbean Journal of Science 20:119–127.

Reynolds, R.G., and G.P. Gerber. 2012. Ecology and conservation of the Turks Island Boa (*Epicrates chrysogaster chrysogaster*: Squamata: Boidae) on Big Ambergris Cay. Journal of Herpetology 46:578–586.

Reynolds, R.G., M.L. Niemiller, S.B. Hedges, A. Dornburg, A.R. Puente-Rolón, and L.J. Revell. 2013. Molecular phylogeny and historical biogeography of West Indian boid snakes (*Chilabothrus*). Molecular Phylogenetics and Evolution 68:461–470.

Reynolds, R.G., A.R. Puente-Rolón, R. Platenberg, R.K. Tyler, P.J. Tolson, and L.J. Revell. 2015. Large divergence and low diversity suggest genetically informed conservation strategies for the endangered Virgin Islands Boa (*Chilabothrus monensis*). Global Ecology and Conservation 3:487–502.

Reynolds, R.G., A.R. Puente-Rolón, K.J. Aviles-Rodriguez, A.J. Geneva, and N.C. Herrmann. 2016. Discovery of a remarkable new boa from the Conception Island Bank, Bahamas. Breviora 549:1–19.

Roe, J.H., J. Gibson, and B.A. Kingsbury. 2006. Beyond the wetland border: Estimating the impacts of roads for two species of water snakes. Biological Conservation 130:161–168.

Rosen, P.C., and C.H. Lowe. 1994. Highway mortality of snakes in the Sonoran Desert of southern Arizona. Biological Conservation 68:143–148.

Row, J.R., G. Blouin-Demers, and P.J. Weatherhead. 2007. Demographic effects of road mortality in Black Ratsnakes (*Elaphe obsoleta*). Biological Conservation 137:117–124.

Schwartz, A., and R.W. Henderson. 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. University of Florida Press, Gainesville, FL, USA.

Shepard, D.B., M.J. Dreslik, B.C. Jellen, and C.A. Phillips. 2008. Reptile road mortality around an oasis in the Illinois Corn Desert with emphasis on the endangered Eastern Massasauga. Copeia 2008:350–359.

Sheplan, B.R., and A. Schwartz. 1974. Hispaniolan boas of the genus Epicrates (Serpentes: Boidae) and their Antillean relationships. Annals of the Carnegie Museum 45:57–143.

Shine, R., M. Lemaster, M. Wall, T. Langkilde, and R. Mason. 2004. Why did the snake cross the road? Effects of roads on movement and location of mates by Garter Snakes (*Thamnophis sirtalis parietalis*). Ecology and Society 9:9.

Snider, A.T., and J.K. Bowler. 1992. Longevity of reptiles and amphibians in North American collections. 2nd Edition. Society for the Study of Amphibians and Reptiles, Herpetological Circular 21:iv–40.

Steen, D.A., and J.P. Gibbs. 2004. Effects of roads on the structure of freshwater turtle populations. *Conservation Biology* 18:1143–1148.

Steen, D.A., M.J. Aresco, S.G. Beilke, B.W. Compton, E.P. Condon, C. Kenneth Dodd Jr., H. Forrester, J.W. Gibbons, J.L. Greene, G. Johnson, T.A. Langen, M.J. Oldham, D.N. Oxier, R.A. Saumure, F.W. Schueler, J.M. Sleeman, L.L. Smith, J.K. Tucker, and J.P. Gibbs. 2006. Relative vulnerability of female turtles to road mortality. Animal Conservation 9:269–273.

Tolson, P.J., and R.W. Henderson. 1993. The Natural History of West Indian Boas. R&A Publishing Ltd., Taunton, Somerset, UK.

Tolson, P.J., and R.W. Henderson. 2011. An overview of snake conservation in the West Indies. Pp. 49–62, *In* A. Hailey, B.S. Wilson, and J.A. Horrocks (Eds.). Conservation of Caribbean Island Herpetofaunas, Vol. 1. Brill, Leiden, The Netherlands.

Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18–30.

Vargas Salinas, F., I.Delgado Ospina, and F. López Aranda. 2011. Mortalidad por atropello vehicular y distibución de anfibios y reptiles en un bosque subandino en el occidente de Colombia. Caldasia 33:121–138.